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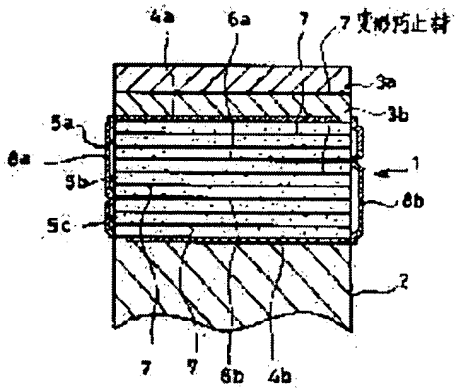
(54) ULTRASONIC WAVE PROBE AND ITS MANUFACTURE

(57)Abstract:

PROBLEM TO BE SOLVED: To attain high accuracy for a finished size by reducing production of a bent of an ultrasonic vibrator of the ultrasonic wave probe consisting of lamination of a plurality of piezoelectric element layers formed to be boards of a prescribed thickness.

SOLUTION: An ultrasonic wave vibrator 1 is formed by laminating a plurality of piezoelectric element layers each formed to be a board of a prescribed thickness, external electrodes 4a, 4b are formed piezoelectric elements 5a-5c laminated in this way and inner flat electrodes 6a, 6b are formed to borders of the layers. One or a plurality of deformation preventing flat members 7 are inserted at an equal interval in the broadwise direction of the piezoelectric elements and the outer electrodes 4a, 4b on the uppermost and the lower most sides are connected to the different inner electrodes 6b, 6c at an interval of one layer and the deformation preventing flat members 7 are insulated and in this state, the entire piezoelectric elements are alternately polarized in opposite direction in the laminating direction.



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*.NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The ultrasonic vibrator which receives that reflected wave while setting forth a supersonic wave, and the backing material from which it is made for the supersonic wave which is formed in the tooth back of this ultrasonic vibrator, and comes out from that tooth back not to return to a trembler side again, In the ultrasound probe which has the acoustic matching layer which is prepared in the front face of the above-mentioned ultrasonic vibrator, and takes adjustment with the acoustic impedance of this ultrasonic vibrator, and a living body's acoustic impedance, and changes While the above-mentioned ultrasonic vibrator carries out two or more layer laminating of the piezoelectric device formed in tabular [of predetermined thickness] and forming an external electrode in this top face and inferior surface of tongue of the whole piezoelectric device by which two or more layer laminating was carried out Form a plate-like internal electrode in the boundary line of each class, respectively, and 1 or two or more plate-like deformation prevention material are inserted at equal intervals into the thickness of each class of the above-mentioned piezoelectric device. While connecting the external electrode of the above-mentioned top face, and an external electrode at the bottom to an internal electrode which is different every other layer, respectively The ultrasound probe characterized by making the whole piezoelectric device by which insulated with the plate-like deformation prevention material in each class, and two or more layer laminating was carried out [above-mentioned] in this condition into the structure polarized in the reverse sense by turns in the direction of a laminating.
[Claim 2] The plate-like deformation prevention material inserted into the thickness of each class of the above-mentioned piezoelectric device is an ultrasound probe according to claim 1 characterized by being what consists of an ingredient the same [a plate-like internal electrode and coefficient of thermal expansion] or equivalent.
[Claim 3] The plate-like deformation prevention material inserted into the thickness of each class of the above-mentioned piezoelectric device is an ultrasound probe according to claim 2 characterized by being what consists of an electrical conducting material or an insulating material.
[Claim 4] Form the piece of a piezoelectric device plate-like by predetermined thickness using piezoelectric material, and printing spreading of the conductive paste for internal electrodes is carried out at one side of this piece of a piezoelectric device. After carrying out the laminating of the piece of a piezoelectric device of two or more sheets which carried out printing spreading of this conductive paste and carrying out heating sticking by pressure, It calcinates at predetermined temperature and the conductive paste for external electrodes can be burned on this top face and inferior surface of tongue of the whole piece of a piezoelectric device by which two or more layer laminating was carried out. While connecting the external electrode of the above-mentioned top face, and an external electrode at the bottom to conductive paste for internal electrodes which is different every [of the same number] two or more layers, respectively Insulate with other conductive paste, and carry out polarization processing of the whole piece of a piezoelectric device by which two or more layer laminating was carried out [above-mentioned] by impressing direct-current quantity electric field between the external electrode on the top face of the account of Gokami, and an external electrode at the bottom, and an ultrasonic vibrator is constituted. While preparing the backing material from which it is made for the supersonic wave which appears from that tooth back in the tooth-back side of this ultrasonic vibrator not to return to a trembler side again The manufacture approach of the ultrasound probe characterized by manufacturing by preparing the acoustic matching layer which takes adjustment with the acoustic impedance of this ultrasonic vibrator, and a living body's acoustic impedance in the front-face side of the above-mentioned ultrasonic vibrator.
[Claim 5] The above-mentioned ultrasonic vibrator is the manufacture approach of the ultrasound probe according to claim 4 characterized by cutting in rectangles by the predetermined pitch and forming in the shape of an array after carrying out polarization processing of the whole piece of a piezoelectric device by which two or more layer laminating was carried out.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the ultrasound probe which can lessen generating of the curvature of the ultrasonic vibrator which carries out two or more layer laminating of the piezoelectric device especially formed in tabular [of predetermined thickness], and changes about the ultrasound probe which receives the reflected wave, and can make dimension size of a result highly precise, and its manufacture approach while setting forth a supersonic wave in an ultrasonic diagnostic equipment etc.
[0002]
[Description of the Prior Art] This conventional kind of ultrasound probe has the backing material 2 from which it is made for the supersonic wave which is formed in the tooth back of the ultrasonic vibrator 1 which receives that reflected wave while setting forth a supersonic wave, as shown in drawing 7 , and this ultrasonic vibrator 1, and comes out from that tooth back not to return to a trembler side again, and the acoustic matching layer 3 which is prepared in the front face of the above-mentioned ultrasonic vibrator 1, and takes adjustment with the acoustic impedance of this ultrasonic vibrator 1, and a living body's acoustic impedance, and changed. In addition, the external electrodes 4a and 4b are formed in the top face and inferior surface of tongue of the above-mentioned ultrasonic vibrator 1, respectively, and the ultrasonic vibrator 1 which consists of piezoelectric material is made to expand and contract in the thickness direction by impressing an electrical potential difference between two-electrodes 4a and 4b. Moreover, in drawing 7 , the ultrasonic vibrator 1 is cut in rectangles by the predetermined pitch, and shows many vibrator components 5 and 5 of this rectangle, and the thing which arranged -- in the shape of an array.
[0003] When using for example, for the probe for an electronic sector scan the vibrator components 5 and 5 of above-mentioned a large number, and the ultrasonic vibrator 1 which arranged -- in the shape of an array, in order to avoid generating of a grating lobe constituting the cause of the artifact of an ultrasonic image of each vibrator components 5 and 5 and -- that a pitch is obtained, it is necessary to make it as small as possible. However, an electric impedance becomes large, while the size of the piezoelectric material per element will become small and electric capacity will become small as a result, if each above-mentioned trembler components 5 and 5 and the pitch of -- are made small. Moreover, in the case of the 2-dimensional array transducer using many vibrator components 5 and 5 and the ultrasonic vibrator 1 which arranged -- in the shape of an array in the direction of two dimension, it becomes still smaller [the size of the piezoelectric material per element]. Such a fall of electric capacity and increase of an electric impedance had bad electric adjustment with the wave transmission circuit system by the side of the body of an ultrasonic diagnostic equipment, and were what electric adjustment is [what] bad and degrades S/N as an ultrasound probe in response to the effect of the capacity of the cable linked to the body of an ultrasonic diagnostic equipment.
[0004] On the other hand, as a policy which suppresses the fall of the electric capacity per element of the above-mentioned ultrasonic vibrator 1, and increase of an electric impedance, as shown in drawing 8 , the piezoelectric material which constitutes an ultrasonic vibrator 1 is formed thinly, and there are two or more layers, for example, the thing of structure which carried out the three-layer laminating (5a, 5b, 5c), and inserted internal electrodes 6a and 6b between each class, about this. In this case, in the laminated structure of three layers, external electrode 4a on top is connected to internal electrode 6b of a two-layer eye, external electrode 4b at the bottom is connected to internal electrode 6a of the 1st layer, and it considers as the structure polarized in the reverse sense by turns in the direction of a laminating. If it does in this way, the piezoelectric devices 5a, 5b, and 5c by which the laminating was carried out to three layers will become in-series acoustically, and will serve as parallel connection electrically. Consequently, in the case of the thickness with the same ultrasonic vibrator 1 of three layers shown in the ultrasonic vibrator 1 and drawing 8 of the monolayer shown in drawing 7 , both resonance frequency becomes equal, but generally, with the piezoelectric

material of a n layer laminating, by 1/n, since the thickness per layer increases n times, electric capacity sets it n2 twice and, as for an electric impedance, area is set to 1/n2 by it.
[0005] And the baking laminated layers method was really which is unified by calcinating to coincidence the piezoelectric devices 5a, 5b, and 5c which carried out two or more layer laminating, and the internal electrodes 6a and 6b inserted between each class as the manufacture approach of the ultrasonic vibrator 1 of such two or more layer laminated structure used.
[0006]
[Problem(s) to be Solved by the Invention] However, it sets to the ultrasonic vibrator 1 of such two or more conventional layer laminated structure. While the curvature of an ultrasonic vibrator 1 occurs after baking by calcinating to coincidence the piezoelectric devices 5a, 5b, and 5c which carried out two or more layer laminating, and the internal electrodes 6a and 6b inserted between each class It was difficult for dispersion and dispersion of thickness to occur and for extent of the curvature to manufacture the ultrasonic vibrator 1 of highly precise dimension size. It was that from which the above-mentioned trouble becomes remarkable, so that the thickness of the piezoelectric material per layer increased especially. As a conventional ultrasound probe, the oscillation mode of single resonance frequency may not be acquired and the good ultrasonic image of image quality might not be obtained from this as an ultrasonic diagnostic equipment.
[0007] Then, this invention copes with such a trouble and aims at offering the ultrasound probe which can lessen generating of the curvature of the ultrasonic vibrator which carries out two or more layer laminating of the piezoelectric device formed in tabular [of predetermined thickness], and changes, and can make dimension size of a result highly precise, and its manufacture approach.
[0008]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, the ultrasound probe by this invention The ultrasonic vibrator which receives that reflected wave while setting forth a supersonic wave, and the backing material from which it is made for the supersonic wave which is formed in the tooth back of this ultrasonic vibrator, and comes out from that tooth back not to return to a trembler side again, In the ultrasound probe which has the acoustic matching layer which is prepared in the front face of the above-mentioned ultrasonic vibrator, and takes adjustment with the acoustic impedance of this ultrasonic vibrator, and a living body's acoustic impedance, and changes While the above-mentioned ultrasonic vibrator carries out two or more layer laminating of the piezoelectric device formed in tabular [of predetermined thickness] and forming an external electrode in this top face and inferior surface of tongue of the whole piezoelectric device by which two or more layer laminating was carried out Form a plate-like internal electrode in the boundary line of each class, respectively, and 1 or two or more plate-like deformation prevention material are inserted at equal intervals into the thickness of each class of the above-mentioned piezoelectric device. While connecting the external electrode of the above-mentioned top face, and an external electrode at the bottom to an internal electrode which is different every other layer, respectively, it insulates with the plate-like deformation prevention material in each class, and the whole piezoelectric device by which two or more layer laminating was carried out [above-mentioned] in this condition is made into the structure polarized in the reverse sense by turns in the direction of a laminating.
[0009] Moreover, the plate-like deformation prevention material inserted into the thickness of each class of the above-mentioned piezoelectric device shall consist of an ingredient the same [a plate-like internal electrode and coefficient of thermal expansion] or equivalent.
[0010] Furthermore, the plate-like deformation prevention material inserted into the thickness of each class of the above-mentioned piezoelectric device shall consist of an electrical conducting material or an insulating material.
[0011] Moreover, the manufacture approach of the ultrasound probe as related invention Form the piece of a piezoelectric device plate-like by predetermined thickness using piezoelectric material, and printing spreading of the conductive paste for internal electrodes is carried out at one side of this piece of a piezoelectric device. After carrying out the laminating of the piece of a piezoelectric device of two or more sheets which carried out printing spreading of this conductive paste and carrying out heating sticking by pressure, It calcinates at predetermined temperature and the conductive paste for external electrodes can be burned on this top face and inferior surface of tongue of the whole piece of a piezoelectric device by which two or more layer laminating was carried out. While connecting the external electrode of the above-mentioned top face, and an external electrode at the bottom to conductive paste for internal electrodes which is different every [of the same number] two or more layers, respectively Insulate with other conductive paste, and carry out polarization processing of the whole piece of a piezoelectric device by which two or more layer laminating was carried out [above-mentioned] by impressing direct-current quantity electric field between the external electrode on the top face of the account of Gokami, and an external electrode at the bottom, and an

ultrasonic vibrator is constituted. While preparing the backing material from which it is made for the supersonic wave which appears from that tooth back in the tooth-back side of this ultrasonic vibrator not to return to a trembler side again It manufactures by preparing the acoustic matching layer which takes adjustment with the acoustic impedance of this ultrasonic vibrator, and a living body's acoustic impedance in the front-face side of the above-mentioned ultrasonic vibrator.

[0012] Furthermore, after carrying out polarization processing of the whole piece of a piezoelectric device by which two or more layer laminating was carried out, the above-mentioned ultrasonic vibrator may be cut in rectangles by the predetermined pitch, and may be formed in the shape of an array.

[0013]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail based on an accompanying drawing. drawing 1 shows the gestalt of operation of the ultrasound probe by this invention -- it is a cross-section perspective view a part. This ultrasound probe receives that reflected wave while setting forth a supersonic wave in an ultrasonic diagnostic equipment etc., and as shown in drawing 1 , it consists of an ultrasonic vibrator 1, the backing material 2, and an acoustic matching layer 3.

[0014] The above-mentioned ultrasonic vibrator 1 receives the reflected wave while setting forth a supersonic wave, and it consists of piezoelectric material which changes electrical energy and ultrasonic energy. As this piezoelectric material, there is electrostrictive ceramics of a zircon lead titanate (PZT) system or electrostrictive ceramics of a lead titanate (PbTiO3) system, for example. The electrostrictive ceramics of a PZT system has that the electromechanical coupling coefficient showing the conversion efficiency of electrical energy and ultrasonic energy is large, and the description of a dielectric constant being large and being easy to take electric impedance matching with an electrical circuit system. Moreover, since oscillating association of the transversal effect is remarkably weak, unnecessary vibration decreases sharply and the electrostrictive ceramics of PbTiO3 system has the description in the point that the transmission-and-reception wave property near the ideal of only thickness longitudinal oscillation is acquired purely.

[0015] It is made for the supersonic wave which is formed in the tooth back of the above-mentioned ultrasonic vibrator 1, and comes out from the tooth back not to return to a vibrator side again, and the backing material 2 is using the large ingredient of attenuation of a supersonic wave. Moreover, an acoustic matching layer 3 is formed in the front face of the above-mentioned ultrasonic vibrator 1, and takes adjustment with the acoustic impedance of this ultrasonic vibrator 1, and a living body's acoustic impedance, and, thereby, vibration of an ultrasonic vibrator 1 can spread it now to a living body efficiently. In addition, two layers of this acoustic matching layer 3 may be prepared. Moreover, although omitted in drawing 1 , an acoustic lens may be prepared in a front face at the pan of the above-mentioned acoustic matching layer 3.

[0016] In addition, the external electrodes 4a and 4b are formed in the top face and inferior surface of tongue of the above-mentioned ultrasonic vibrator 1, respectively, by impressing an electrical potential difference between two-electrodes 4a and 4b, the ultrasonic vibrator 1 which consists of piezoelectric material is made to expand and contract in the thickness direction, and a supersonic wave is generated. Moreover, in drawing 1 , the ultrasonic vibrator 1 is cut in rectangles by the predetermined pitch, and shows many vibrator components 5 and 5 of this rectangle, and the thing which arranged -- in the shape of an array.

[0017] It sets to this invention here. The above-mentioned ultrasonic vibrator 1 As shown in drawing 2 , while carrying out two or more layer laminating of the piezoelectric devices 5a, 5b, and 5c formed in tabular [of predetermined thickness] and forming the external electrodes 4a and 4b in this top face and inferior surface of tongue of the whole piezoelectric devices 5a-5c by which two or more layer laminating was carried out The plate-like internal electrodes 6a and 6b are formed in the boundary line of each class, respectively, and 1 or two or more plate-like deformation prevention material 7 and 7, and -- are inserted at equal intervals into the thickness of each class of the above-mentioned piezoelectric devices 5a, 5b, and 5c.

[0018] That is, the three-layer laminating of the piezoelectric devices 5a, 5b, and 5c whose thickness of one layer is about 0.21mm, for example is carried out, and the plate-like internal electrodes 6a and 6b are formed in the boundary line of each class 5a, 5b, and 5c, respectively, and the plate-like deformation prevention material 7 and 7 of two sheets and -- are inserted for example, at intervals of 0.07mm into the thickness of each piezoelectric devices 5a, 5b, and 5c. Therefore, the ultrasonic vibrator 1 by the example of drawing 2 carries out the nine-sheet laminating of the piezoelectric device with a thickness of 0.07mm, and becomes the thickness of about 0.63mm on the whole. And the above-mentioned deformation prevention material 7 and 7 and -- are made of the same ingredient as internal electrodes 6a and 6b, and consist of an electrical conducting material with the same internal electrodes 6a and 6b and coefficient of thermal expansion.

[0019] While connecting external electrode 4a of the above-mentioned top face, and external electrode 4b at the bottom

in such the condition to internal electrodes 6a and 6b which are different every other layer, respectively, it insulates with the plate-like deformation prevention material 7 and 7 in each class, and --. That is, flank electrode 8b of another side where flank electrode 8a is prepared, a part of this flank electrode 8a is connected to internal electrode 6b of a two-layer eye, and while following external electrode 4a on top follows external electrode 4b at the bottom is prepared, and a part of this flank electrode 8b is connected to internal electrode 6a of the 1st layer. At this time, except the part linked to internal electrode 6b of a two-layer eye, it fills up with an insulating material and one flank electrode 8a is insulated with other internal electrode 6a and the deformation prevention material 7 and 7, and --. Moreover, except the part linked to internal electrode 6a of the 1st layer, it fills up with an insulating material and flank electrode 8b of another side is insulated with other internal electrode 6b and the deformation prevention material 7 and 7, and --. Thereby, external electrode 4a on top is connected only to internal electrode 6b of a two-layer eye, and external electrode 4b at the bottom is connected only to internal electrode 6a of the 1st layer. Consequently, the piezoelectric devices 5a, 5b, and 5c by which the laminating was carried out to three layers become in-series acoustically, and serve as parallel connection electrically.

[0020] And the whole piezoelectric devices 5a-5c by which two or more layer laminating was carried out [above-mentioned] in this condition are made into the structure polarized in the reverse sense by turns in the direction of a laminating. That is, direct-current quantity electric field are impressed between external electrode 4a on top and external electrode 4b at the bottom, polarization processing is performed, each class of piezoelectric devices 5a-5c is polarized, and it gives piezoelectric. Thereby, the ultrasonic vibrator 1 concerning this invention is constituted. In this case, by existence, generating of the curvature at the time of calcinating the whole piezoelectric devices 5a-5c of the piezoelectric devices 5a and 5b of each class, the deformation prevention material 7 and 7 inserted into 5c, and -- by which two or more layer laminating was carried out can be lessened, and dimension size of a result can be made highly precise. In addition, in drawing 2 , the case where an acoustic matching layer 3 is formed two-layer (3a, 3b) is shown.

[0021] In addition, ****** [the number of them / what] in drawing 1 and drawing 2 as long as this invention is two or more layers not only this but more than two-layer although the ultrasonic vibrator 1 should carry out the three-layer (a [5],b [5], 5c) laminating of the piezoelectric device. Moreover, the piezoelectric devices 5a and 5b of each class, the deformation prevention material 7 and 7 inserted into 5c, and -- may also be not only two sheets but how many sheets. Furthermore, the above-mentioned deformation prevention material 7 may consist of the ingredient of the coefficient of thermal expansion of not only this but an abbreviation EQC, although internal electrodes 6a and 6b and coefficient of thermal expansion shall consist of the same ingredient. The above-mentioned deformation prevention material 7 may be whichever of an electrical conducting material or an insulating material further again, if internal electrodes 6a and 6b and coefficient of thermal expansion consist of a same or equivalent ingredient. If the deformation prevention material 7 is an insulating material, in above-mentioned explanation, it does not need to be filled up with an insulating material between the medial surface of the flank electrodes 8a and 8b, and the edge of the above-mentioned deformation prevention material 7.

[0022] Next, the manufacture approach of the ultrasound probe as related invention of the above-mentioned ultrasound probe is explained with reference to drawing 3 and drawing 4 . First, in drawing 3 , the pieces 9 and 9 of a piezoelectric device plate-like by predetermined thickness and -- are formed using piezoelectric material. That is, using the electrostrictive ceramics powder of a PZT system or PbTiO3 system as a piezoelectric material, an organic binder is added to this and the piece 9 of a piezoelectric device plate-like by predetermined thickness is produced by the process called a doctor blade method. What is necessary is just to set up that thickness in consideration of contraction at future sticking-by-pressure baking processes, at this time, so that it may become 0.07mm in predetermined thickness, for example, thickness, even if it does not grind after baking.

[0023] Next, the laminating of the pieces 9 and 9 of a piezoelectric device of two or more sheets and -- which carried out printing spreading of the conductive paste 10 used as the internal electrodes 6a and 6b shown in one side of the above-mentioned piece 9 of a piezoelectric device at drawing 2 , and carried out printing spreading of this conductive paste 10 is carried out, and heating sticking by pressure is carried out. That is, this silver palladium etc. is applied to the whole front face of the piece 9 of a piezoelectric device by screen-stencil etc., using ingredients, such as silver palladium, as conductive paste 10. At this time, printing spreading of the above-mentioned conductive paste 10 is not carried out in the front face of the piece 9 of a piezoelectric device located in the top. And after drying the pieces 9 and 9 of a piezoelectric device and -- which carried out printing spreading of the above-mentioned conductive paste 10, the laminating of the piece 9 of a piezoelectric device of nine sheets is carried out, and heating sticking by pressure is carried out in metal mold.

[0024] Next, these pieces 9 and 9 of a piezoelectric device by which heating sticking by pressure was carried out, and the layered product of -- are calcinated at predetermined temperature. At this time, the organic binder in the piece 9 of a

piezoelectric device is removed, carrying out a temperature up gradually, and it calcinates at 1150 degrees C for 5 hours further, for example. And the pieces 9 and 9 of a piezoelectric device and the dimension of a request of the appearance of a layered product of -- are processed after this baking.

[0025] Next, by the ability burning the conductive paste for external electrode 4a and 4b on a whole top face and a whole inferior surface of tongue, while connecting to the conductive paste internal electrode 6a of the pieces 9 and 9 of a piezoelectric device by which two or more layer laminating was carried out [above-mentioned], and -- which is different every [of the same number] two or more layers, respectively in external electrode 4a of the above-mentioned top face, and external electrode 4b at the bottom, and for 6b, it insulates with other conductive paste. In addition, the above-mentioned external electrodes 4a and 4b may form an electrical conducting material by vacuum evaporationo or plating. And in this example, as shown in drawing 4 , it counts from the bottom among those which carried out the laminating of the piece 9 of a piezoelectric device of nine sheets in drawing 3 , the conductive paste applied to one side of the piece 9 of a piezoelectric device of the 6th sheet with the 3rd sheet is used as internal electrodes 6b and 6a, respectively, and all the conductive paste applied to one side of the other piece 9 of a piezoelectric device is made into the deformation prevention material 7.

[0026] And flank electrode 8b of another side where flank electrode 8a is prepared by printing etc., and a part of this flank electrode 8a is connected to one internal electrode 6b, and while following external electrode 4a on top follows external electrode 4b at the bottom is prepared by printing etc., and a part of this flank electrode 8b is connected to internal electrode 6a of another side. At this time, except the part linked to the above-mentioned internal electrode 6b, it fills up with an insulating material and one flank electrode 8a is insulated with other internal electrode 6a and the deformation prevention material 7 and 7, and --. Moreover, except the part linked to the above-mentioned internal electrode 6a, it fills up with an insulating material and flank electrode 8b of another side is insulated with other internal electrode 6b and the deformation prevention material 7 and 7, and --. Thereby, external electrode 4a on top is connected only to one internal electrode 6b, and external electrode 4b at the bottom is connected only to internal electrode 6a of another side. Consequently, the piezoelectric devices 5a, 5b, and 5c by which the laminating was carried out to three layers bordering on the above-mentioned internal electrodes 6a and 6b become in-series acoustically, and serve as parallel connection electrically.

[0027] Then, polarization processing of the pieces 9 and 9 of a piezoelectric device by which two or more layer laminating was carried out [above-mentioned] by impressing direct-current quantity electric field between external electrode 4a of the above-mentioned top face and external electrode 4b at the bottom, and whole -- is carried out, piezoelectric is given, and an ultrasonic vibrator 1 is constituted. In this case, by existence, in case the whole piezoelectric devices 5a-5c of the piezoelectric devices 5a and 5b of each class, the deformation prevention material 7 and 7 inserted into 5c, and -- by which two or more layer laminating was carried out are calcinated, generating of curvature can be lessened, and dimension size of a result can be made highly precise. Thus, the produced ultrasonic vibrator 1 serves as the ultrasonic vibrator of the laminated structure of three layers and equivalence from which the thickness of the piezoelectric devices 5a, 5b, and 5c by which the laminating was carried out to three layers bordering on the above-mentioned internal electrodes 6a and 6b is set to 0.21mm, respectively, and the whole thickness is set to 0.63mm.

[0028] Then, as shown in drawing 2 , while forming the backing material 2 from which it is made for the supersonic wave which appears from the tooth back in the tooth-back side of the above-mentioned ultrasonic vibrator 1 not to return to a trembler side again, the acoustic matching layers 3a and 3b which take adjustment with the acoustic impedance of this ultrasonic vibrator 1 and a living body's acoustic impedance are formed in the front-face side of the above-mentioned ultrasonic vibrator 1. Thereby, the ultrasound probe of this invention is manufactured.

[0029] In addition, in the production process of the above-mentioned ultrasound probe, as shown in drawing 4 , it may cut to the predetermined pitches p and p in the place where the ultrasonic vibrator 1 was produced, and this ultrasonic vibrator 1 may be cut in rectangles by --, and you may form in the shape of an array. In this case, the ultrasound probe of an electronic-raster-scanning mold which arranged many vibrator components in the shape of an array can be manufactured.

[0030] Drawing 5 and drawing 6 are the explanatory views showing other examples of the manufacture approach of an ultrasound probe. Fundamentally, although the manufacture approach by this example is the same as the manufacture approach shown in drawing 3 and drawing 4 , in case it carries out printing spreading of the conductive paste 10 used as the internal electrodes 6a and 6b shown in one side of the above-mentioned piece 9 of a piezoelectric device at drawing 2 after it forms the pieces 9 and 9 of a piezoelectric device plate-like by predetermined thickness, and -- using piezoelectric material, it forms the insulating part 11 by which conductive paste 10 is not applied to both that side part. In addition, in case printing spreading of the conductive paste 10 which serves as the internal electrodes 6a and 6b

actually shown in drawing 2 at this time is carried out, it is made not to form an insulating part 11 in the side linked to the external electrodes 8a and 8b.

[0031] In such the condition, as shown in drawing 6 , while carrying out the laminating of the piece of a piezoelectric device of nine layers, internal electrodes 6a and 6b and the deformation prevention material 7 and 7, and -- are formed, and the external electrodes 4a and 4b are formed in a top face and an inferior surface of tongue, and the flank electrodes 8a and 8b are further formed in a both-sides side. And flank electrode 8a which follows external electrode 4a on top is connected to one internal electrode 6b, and flank electrode 8b which follows external electrode 4b at the bottom is connected to internal electrode 6a of another side. Thus, by manufacturing, it does not require being filled up with an insulating material in drawing 4 between the medial surface of the flank electrodes 8a and 8b, and the side edge section of the piece of a piezoelectric device of nine layers, but a production process can be simplified.

[0032]

[Effect of the Invention] Since the ultrasound probe by this invention was constituted as mentioned above, while carrying out two or more layer laminating of the piezoelectric device formed in tabular [of predetermined thickness] in that ultrasonic vibrator and forming an external electrode in this top face and inferior surface of tongue of the whole piezoelectric device by which two or more layer laminating was carried out Form a plate-like internal electrode in the boundary line of each class, respectively, and 1 or two or more plate-like deformation prevention material are inserted at equal intervals into the thickness of each class of the above-mentioned piezoelectric device. While connecting the external electrode of the above-mentioned top face, and an external electrode at the bottom to an internal electrode which is different every other layer, respectively By having insulated with the plate-like deformation prevention material in each class, and having made the whole piezoelectric device by which two or more layer laminating was carried out [above-mentioned] in this condition into the structure polarized in the reverse sense by turns in the direction of a laminating While being able to make thin substantially thickness per [in which two or more layer laminating was carried out by insertion of the above-mentioned deformation prevention material] layer, by existence of the deformation prevention material, generating of the curvature at the time of calcinating the whole piezoelectric device by which two or more layer laminating was carried out [above-mentioned] can be lessened, and dimension size of a result can be made highly precise. Therefore, according to the ultrasound probe by this invention, the oscillation mode of single resonance frequency is acquired and the good ultrasonic image of image quality can be obtained as an ultrasonic diagnostic equipment.

[0033] Especially when an internal electrode and coefficient of thermal expansion shall consist the deformation prevention material inserted into the thickness of each class of the above-mentioned piezoelectric device of a same or equivalent ingredient, generating of the curvature at the time of calcinating the whole piezoelectric device by which two or more layer laminating was carried out can be lessened further, and dimension size of a result can be made still highly precise.

[0034] Moreover, according to the manufacture approach of the ultrasound probe by this invention, generating of the curvature at the time of calcinating the whole piezoelectric device by which two or more layer laminating was carried out can be lessened, and the dimension size of a result can produce a highly precise ultrasonic vibrator easily.

[Translation done.]

JAPANESE [JP,09-327096,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS DESCRIPTION OF DRAWINGS DRAWINGS CORRECTION OR AMENDMENT

[Translation done.]

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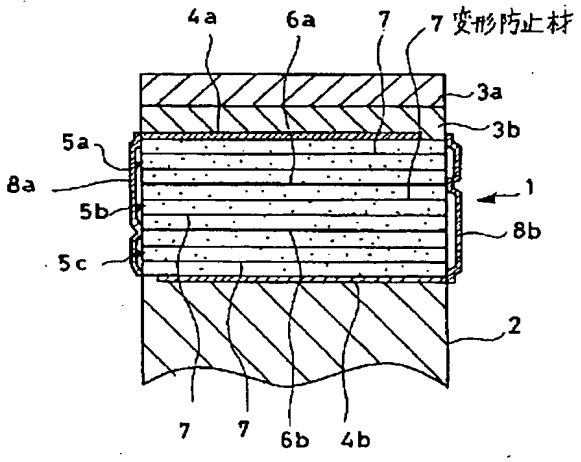
(54) 【発明の名称】超音波探触子及びその製造方法

(57) 【要約】　（修正有）

【課題】　超音波探触子において、所定の厚さの板状に形成された圧電素子を複数層積層して成る超音波振動子の反りの発生を少なくして仕上がりの寸法サイズを高精度とする。

【解決手段】　超音波振動子１を、所定の厚さの板状に形成された圧電素子を複数層積層し、この複数層積層された圧電素子５ａ～５ｃの全体の上面及び下面に外部電極４ａ，４ｂを形成すると共に、各層の境目には平板状の内部電極６ａ，６ｂを形成し、かつ上記圧電素子の各層の厚み内には一又は複数の平板状の変形防止材７を等間隔で挿入し、上記上面及び下面の外部電極４ａ，４ｂをそれぞれ１層おきに異なる内部電極６ｂ，６ａに対し接続すると共に、各層内の平板状の変形防止材７とは絶縁し、この状態で上記複数層積層された圧電素子の全体を積層方向に交互に逆向きに分極した構造とする。



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【特許請求の範囲】

【請求項１】　超音波を打ち出すと共にその反射波を受信する超音波振動子と、この超音波振動子の背面に設けられその背面から出る超音波が再び振動子面に戻ってこないようにするバッキング材と、上記超音波振動子の前面に設けられ該超音波振動子の音響インピーダンスと生体の音響インピーダンスとの整合をとる音響整合層とを有して成る超音波探触子において、上記超音波振動子は、所定の厚さの板状に形成された圧電素子を複数層積層し、この複数層積層された圧電素子の全体の上面及び下面に外部電極を形成すると共に、各層の境目には平板状の内部電極をそれぞれ形成し、かつ上記圧電素子の各層の厚み内には一又は複数の平板状の変形防止材を等間隔で挿入し、上記上面の外部電極及び下面の外部電極をそれぞれ１層おきに異なる内部電極に対し接続すると共に、各層内の平板状の変形防止材とは絶縁し、この状態で上記複数層積層された圧電素子の全体を積層方向に交互に逆向きに分極した構造としたことを特徴とする超音波探触子。

【請求項２】　上記圧電素子の各層の厚み内に挿入された平板状の変形防止材は、平板状の内部電極と熱膨張率が同一又は同等の材料から成るものであることを特徴とする請求項１記載の超音波探触子。

【請求項３】　上記圧電素子の各層の厚み内に挿入された平板状の変形防止材は、導電材料又は絶縁材料から成るものであることを特徴とする請求項２記載の超音波探触子。

【請求項４】　圧電材料を用いて所定の厚さで平板状の圧電素子片を形成し、この圧電素子片の片面に内部電極用の導電ペーストを印刷塗布し、この導電ペーストを印刷塗布した複数枚の圧電素子片を積層して加熱圧着した後、所定温度で焼成し、この複数層積層された圧電素子片の全体の上面及び下面に外部電極用の導電ペーストを焼き付け、上記上面の外部電極及び下面の外部電極をそれぞれ同数の複数層おきに異なる内部電極用の導電ペーストに対し接続すると共に、その他の導電ペーストとは絶縁し、その後上記上面の外部電極と下面の外部電極との間に直流高電界を印加して上記複数層積層された圧電素子片の全体を分極処理して超音波振動子を構成し、この超音波振動子の背面側にその背面から出る超音波が再び振動子面に戻ってこないようにするバッキング材を設けると共に、上記超音波振動子の前面側には該超音波振動子の音響インピーダンスと生体の音響インピーダンスとの整合をとる音響整合層を設けることにより製造することを特徴とする超音波探触子の製造方法。

【請求項５】　上記超音波振動子は、複数層積層された圧電素子片の全体を分極処理した後に、所定のピッチ幅で短冊形に切断してアレイ状に形成することを特徴とする請求項４記載の超音波探触子の製造方法。

【発明の詳細な説明】

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【０００１】

【発明の属する技術分野】本発明は、超音波診断装置等において超音波を打ち出すと共にその反射波を受信する超音波探触子に関し、特に所定の厚さの板状に形成された圧電素子を複数層積層して成る超音波振動子の反りの発生を少なくして仕上がりの寸法サイズを高精度とすることができる超音波探触子及びその製造方法に関する。

【０００２】

【従来の技術】従来のこの種の超音波探触子は、図７に示すように、超音波を打ち出すと共にその反射波を受信する超音波振動子１と、この超音波振動子１の背面に設けられその背面から出る超音波が再び振動子面に戻ってこないようにするバッキング材２と、上記超音波振動子１の前面に設けられ該超音波振動子１の音響インピーダンスと生体の音響インピーダンスとの整合をとる音響整合層３とを有して成っていた。なお、上記超音波振動子１の上面及び下面には、それぞれ外部電極４ａ，４ｂが設けられており、両電極４ａ，４ｂ間に電圧を印加することにより、圧電材料から成る超音波振動子１をその厚さ方向に伸縮させるようになっている。また、図７においては、超音波振動子１は所定のピッチ幅で短冊形に切断されており、この短冊形の多数の振動子素子５，５，…をアレイ状に配列したものを示している。

【０００３】上記多数の振動子素子５，５，…をアレイ状に配列した超音波振動子１を例えば電子セクタ走査用探触子に用いる場合、各振動子素子５，５，…のピッチ幅は、得られる超音波画像のアーチファクトの原因となるグレイティングローブの発生を避けるためにできるだけ小さくする必要がある。しかし、上記各振動子素子５，５，…のピッチ幅を小さくすると、１素子当たりの圧電材料のサイズは小さくなり、その結果電気的容量が小さくなる一方、電気的インピーダンスは大きくなる。また、多数の振動子素子５，５，…を二次元方向にアレイ状に配列した超音波振動子１を用いた二次元アレイ探触子の場合は、１素子当たりの圧電材料のサイズはさらに小さくなる。このような、電気的容量の低下及び電気的インピーダンスの増大は、超音波診断装置本体側の送波回路系との電気的整合が悪く、また超音波診断装置本体と接続するケーブルの容量の影響を受けて電気的整合が悪く、超音波探触子としてのＳ／Ｎを劣化させるものであった。

【０００４】これに対し、上記超音波振動子１の１素子当たりの電気的容量の低下及び電気的インピーダンスの増大を抑える方策として、図８に示すように、超音波振動子１を構成する圧電材料を薄く形成し、これを複数層たとえば３層積層し（５ａ，５ｂ，５ｃ）、各層の間に内部電極６ａ，６ｂを挿入した構造のものがある。この場合、３層の積層構造では、上面の外部電極４ａを２層目の内部電極６ｂに接続し、下面の外部電極４ｂを１層目の内部電極６ａに接続して、積層方向に交互に逆向き

に分極した構造とされている。このようにすると、３層に積層された圧電素子５ａ，５ｂ，５ｃが音響的には直列となり、電気的には並列接続となる。この結果、図７に示す単層の超音波振動子１と図８に示す３層の超音波振動子１とが同じ厚さの場合には、両者の共振周波数は等しくなるが、一般にｎ層積層の圧電材料では１層当たりの厚さが１／ｎで面積がｎ倍になるため、電気的容量はｎ^{2}倍、電気的インピーダンスは１／ｎ^{2}となる。

【０００５】そして、このような複数層積層構造の超音波振動子１の製造方法としては、複数層積層した圧電素子５ａ，５ｂ，５ｃと各層間に挿入された内部電極６ａ，６ｂとを同時に焼成することにより一体化する一体焼成積層法が用いられていた。

【０００６】

【発明が解決しようとする課題】しかし、このような従来の複数層積層構造の超音波振動子１においては、複数層積層した圧電素子５ａ，５ｂ，５ｃと各層間に挿入された内部電極６ａ，６ｂとを同時に焼成することにより、焼成後に超音波振動子１の反りが発生すると共に、その反りの程度がばらつき、且つ厚みのばらつきが発生し、高精度の寸法サイズの超音波振動子１を製造するのが難しかった。特に、１層当たりの圧電材料の厚さが増すほど上記の問題点が顕著となるものであった。このことから、従来の超音波探触子としては、単一共振周波数の振動モードが得られないことがあり、超音波診断装置として画質のよい超音波画像が得られないことがあった。

【０００７】そこで、本発明は、このような問題点に対処し、所定の厚さの板状に形成された圧電素子を複数層積層して成る超音波振動子の反りの発生を少なくして仕上がりの寸法サイズを高精度とすることができる超音波探触子及びその製造方法を提供することを目的とする。

【０００８】

【課題を解決するための手段】上記目的を達成するために、本発明による超音波探触子は、超音波を打ち出すと共にその反射波を受信する超音波振動子と、この超音波振動子の背面に設けられその背面から出る超音波が再び振動子面に戻ってこないようにするバッキング材と、上記超音波振動子の前面に設けられ該超音波振動子の音響インピーダンスと生体の音響インピーダンスとの整合をとる音響整合層とを有して成る超音波探触子において、上記超音波振動子は、所定の厚さの板状に形成された圧電素子を複数層積層し、この複数層積層された圧電素子の全体の上面及び下面に外部電極を形成すると共に、各層の境目には平板状の内部電極をそれぞれ形成し、かつ上記圧電素子の各層の厚み内には一又は複数の平板状の変形防止材を等間隔で挿入し、上記上面の外部電極及び下面の外部電極をそれぞれ１層おきに異なる内部電極に対し接続すると共に、各層内の平板状の変形防止材とは絶縁し、この状態で上記複数層積層された圧電素子の全

体を積層方向に交互に逆向きに分極した構造としたものである。

【０００９】また、上記圧電素子の各層の厚み内に挿入された平板状の変形防止材は、平板状の内部電極と熱膨張率が同一又は同等の材料から成るものとする。

【００１０】さらに、上記圧電素子の各層の厚み内に挿入された平板状の変形防止材は、導電材料又は絶縁材料から成るものとする。

【００１１】また、関連発明としての超音波探触子の製造方法は、圧電材料を用いて所定の厚さで平板状の圧電素子片を形成し、この圧電素子片の片面に内部電極用の導電ペーストを印刷塗布し、この導電ペーストを印刷塗布した複数枚の圧電素子片を積層して加熱圧着した後、所定温度で焼成し、この複数層積層された圧電素子片の全体の上面及び下面に外部電極用の導電ペーストを焼き付け、上記上面の外部電極及び下面の外部電極をそれぞれ同数の複数層おきに異なる内部電極用の導電ペーストに対し接続すると共に、その他の導電ペーストとは絶縁し、その後上記上面の外部電極と下面の外部電極との間に直流高電界を印加して上記複数層積層された圧電素子片の全体を分極処理して超音波振動子を構成し、この超音波振動子の背面側にその背面から出る超音波が再び振動子面に戻ってこないようにするバッキング材を設けると共に、上記超音波振動子の前面側には該超音波振動子の音響インピーダンスと生体の音響インピーダンスとの整合をとる音響整合層を設けることにより製造するものである。

【００１２】さらに、上記超音波振動子は、複数層積層された圧電素子片の全体を分極処理した後に、所定のピッチ幅で短冊形に切断してアレイ状に形成してもよい。

【００１３】

【発明の実施の形態】以下、本発明の実施の形態を添付図面に基づいて詳細に説明する。図１は本発明による超音波探触子の実施の形態を示す一部断面斜視図である。この超音波探触子は、超音波診断装置等において超音波を打ち出すと共にその反射波を受信するもので、図１に示すように、超音波振動子１と、バッキング材２と、音響整合層３とから成る。

【００１４】上記超音波振動子１は、超音波を打ち出すと共にその反射波を受信するもので、電気エネルギーと超音波エネルギーとを変換する圧電材料で構成されている。この圧電材料としては、例えばジルコン・チタン酸鉛（ＰＺＴ）系の圧電セラミックス又はチタン酸鉛（$PbTiO_3$）系の圧電セラミックスなどがある。ＰＺＴ系の圧電セラミックスは、電気エネルギーと超音波エネルギーとの変換効率を表わす電気機械結合係数が大きいことと、誘電率が大きく電気回路系との電気的インピーダンス整合がとりやすいという特徴がある。また、$PbTiO_3$系の圧電セラミックスは、横効果の振動結合が著しく弱いことから、不要振動が激減し、純粋に厚み縦振動

のみの理想に近い送受波特性が得られる点に特徴がある。

【００１５】バッキング材２は、上記超音波振動子１の背面に設けられその背面から出る超音波が再び振動子面に戻ってこないようにするもので、超音波の減衰の大きい材料を使用している。また、音響整合層３は、上記超音波振動子１の前面に設けられ該超音波振動子１の音響インピーダンスと生体の音響インピーダンスとの整合をとるもので、これにより超音波振動子１の振動が効率よく生体に伝播できるようになる。なお、この音響整合層３は、２層設けてもよい。また、図１では省略しているが、上記音響整合層３のさらに前面に音響レンズを設けてもよい。

【００１６】なお、上記超音波振動子１の上面及び下面には、それぞれ外部電極４ａ，４ｂが設けられており、両電極４ａ，４ｂ間に電圧を印加することにより、圧電材料から成る超音波振動子１をその厚さ方向に伸縮させて超音波を発生させるようになっている。また、図１においては、超音波振動子１は所定のピッチ幅で短冊形に切断されており、この短冊形の多数の振動子素子５，５，…をアレイ状に配列したものを示している。

【００１７】ここで、本発明においては、上記超音波振動子１は、図２に示すように、所定の厚さの板状に形成された圧電素子５ａ，５ｂ，５ｃを複数層積層し、この複数層積層された圧電素子５ａ～５ｃの全体の上面及び下面に外部電極４ａ，４ｂを形成すると共に、各層の境目には平板状の内部電極６ａ，６ｂをそれぞれ形成し、かつ上記圧電素子５ａ，５ｂ，５ｃの各層の厚み内には一又は複数の平板状の変形防止材７，７，…が等間隔で挿入されている。

【００１８】すなわち、例えば１層の厚さが0.21mm程度の圧電素子５ａ，５ｂ，５ｃを３層積層し、各層５ａ，５ｂ，５ｃの境目には平板状の内部電極６ａ，６ｂをそれぞれ形成し、かつ各圧電素子５ａ，５ｂ，５ｃの厚み内には例えば0.07mm間隔で２枚の平板状の変形防止材７，７，…が挿入されている。従って、図２の例による超音波振動子１は、例えば0.07mmの厚さの圧電素子を９枚積層して、全体で約0.63mmの厚さになる。そして、上記変形防止材７，７，…は、内部電極６ａ，６ｂと同一の材料でできており、その内部電極６ａ，６ｂと熱膨張率が同一の導電材料から成る。

【００１９】このような状態で、上記上面の外部電極４ａ及び下面の外部電極４ｂをそれぞれ１層おきに異なる内部電極６ａ，６ｂに対し接続すると共に、各層内の平板状の変形防止材７，７，…とは絶縁する。すなわち、上面の外部電極４ａと連続する一方の側部電極８ａを設け、この側部電極８ａの一部を２層目の内部電極６ｂに接続し、下面の外部電極４ｂと連続する他方の側部電極８ｂを設け、この側部電極８ｂの一部を１層目の内部電極６ａに接続する。このとき、一方の側部電極８ａは、２層目の内部電極６ｂに接続する部分以外は絶縁物が充填されるなどして他の内部電極６ａ及び変形防止材７，７，…とは絶縁されている。また、他方の側部電極８ｂは、１層目の内部電極６ａに接続する部分以外は絶縁物が充填されるなどして他の内部電極６ｂ及び変形防止材７，７，…とは絶縁されている。これにより、上面の外部電極４ａは２層目の内部電極６ｂにのみ接続され、下面の外部電極４ｂは１層目の内部電極６ａにのみ接続される。この結果、３層に積層された圧電素子５ａ，５ｂ，５ｃが音響的には直列となり、電気的には並列接続となる。

【００２０】そして、この状態で上記複数層積層された圧電素子５ａ～５ｃの全体を積層方向に交互に逆向きに分極した構造とする。すなわち、上面の外部電極４ａと下面の外部電極４ｂとの間に直流高電界を印加して分極処理を行い、圧電素子５ａ～５ｃの各層を分極し、圧電性を付与する。これにより、本発明に係る超音波振動子１が構成される。この場合、各層の圧電素子５ａ，５ｂ，５ｃ内に挿入された変形防止材７，７，…の存在により、複数層積層された圧電素子５ａ～５ｃの全体を焼成する際の反りの発生を少なくし、仕上がりの寸法サイズを高精度とすることができる。なお、図２においては、音響整合層３を２層（３ａ，３ｂ）設けた場合を示している。

【００２１】なお、図１及び図２においては、超音波振動子１は、圧電素子を３層（５ａ，５ｂ，５ｃ）積層したものとしたが、本発明はこれに限らず、２層以上の複数層であれば何層でもよい。また、各層の圧電素子５ａ，５ｂ，５ｃ内に挿入する変形防止材７，７，…も２枚に限らず、何枚であってもよい。さらに、上記変形防止材７は、内部電極６ａ，６ｂと熱膨張率が同一の材料から成るものとしたが、これに限らず、略同等の熱膨張率の材料から成るものであってもよい。さらにまた、上記変形防止材７は、内部電極６ａ，６ｂと熱膨張率が同一又は同等の材料から成るものであるならば、導電材料又は絶縁材料のどちらであってもよい。変形防止材７が絶縁材料であるならば、上述の説明において、側部電極８ａ，８ｂの内側面と上記変形防止材７の端部との間に絶縁物を充填する必要はない。

【００２２】次に、上記超音波探触子の関連発明としての超音波探触子の製造方法について、図３及び図４を参照して説明する。まず、図３において、圧電材料を用いて所定の厚さで平板状の圧電素子片９，９，…を形成する。すなわち、圧電材料としてＰＺＴ系又は$PbTiO_3$系の圧電セラミックス粉末を用い、これに有機バインダを加え、ドクターブレード法と呼ばれる製法により所定の厚さで平板状の圧電素子片９を作製する。このとき、その厚さは以後の圧着焼成工程での収縮を考慮し、焼成後に研磨しなくても所定の厚さ、例えば厚さ0.07mmとなるように設定すればよい。

【００２３】次に、上記圧電素子片９の片面に図２に示す内部電極６ａ，６ｂとなる導電ペースト１０を印刷塗布し、この導電ペースト１０を印刷塗布した複数枚の圧電素子片９，９，…を積層して加熱圧着する。すなわち、導電ペースト１０として銀パラジウム等の材料を用い、この銀パラジウム等をスクリーン印刷等により、圧電素子片９の表面全体に塗布する。このとき、一番上に位置する圧電素子片９の表面には上記の導電ペースト１０を印刷塗布しない。そして、上記導電ペースト１０を印刷塗布した圧電素子片９，９，…を乾燥した後、例えば９枚の圧電素子片９を積層し、金型中で加熱圧着する。

【００２４】次に、この加熱圧着された圧電素子片９，９，…の積層体を所定温度で焼成する。このとき、徐々に昇温しながら圧電素子片９中の有機バインダを除去し、さらに例えば1150℃で５時間焼成する。そして、この焼成後に、圧電素子片９，９，…の積層体の外形を所望の寸法に加工する。

【００２５】次に、上記複数層積層された圧電素子片９，９，…の全体の上面及び下面に外部電極４ａ，４ｂ用の導電ペーストを焼き付け、上記上面の外部電極４ａ及び下面の外部電極４ｂをそれぞれ同数の複数層おきに異なる内部電極６ａ，６ｂ用の導電ペーストに対し接続すると共に、その他の導電ペーストとは絶縁する。なお、上記外部電極４ａ，４ｂは導電材料を蒸着又はメッキ等により形成してもよい。そして、この実施例では図４に示すように、図３において９枚の圧電素子片９を積層したもののうち、下から数えて３枚目と６枚目の圧電素子片９の片面に塗布された導電ペーストはそれぞれ内部電極６ｂ，６ａとし、それ以外の圧電素子片９の片面に塗布された導電ペーストは総て変形防止材７としている。

【００２６】そして、上面の外部電極４ａと連続する一方の側部電極８ａを焼付け等により設け、この側部電極８ａの一部を一方の内部電極６ｂに接続し、また下面の外部電極４ｂと連続する他方の側部電極８ｂを焼付け等により設け、この側部電極８ｂの一部を他方の内部電極６ａに接続する。このとき、一方の側部電極８ａは、上記内部電極６ｂに接続する部分以外は絶縁物が充填されるなどして他の内部電極６ａ及び変形防止材７，７，…とは絶縁されている。また、他方の側部電極８ｂは、上記内部電極６ａに接続する部分以外は絶縁物が充填されるなどして他の内部電極６ｂ及び変形防止材７，７，…とは絶縁されている。これにより、上面の外部電極４ａは一方の内部電極６ｂにのみ接続され、下面の外部電極４ｂは他方の内部電極６ａにのみ接続される。この結果、上記内部電極６ａ，６ｂを境にして３層に積層された圧電素子５ａ，５ｂ，５ｃが音響的には直列となり、電気的には並列接続となる。

【００２７】その後、上記上面の外部電極４ａと下面の外部電極４ｂとの間に直流高電界を印加して上記複数層積層された圧電素子片９，９，…の全体を分極処理して圧電性を付与し、超音波振動子１を構成する。この場合、各層の圧電素子５ａ，５ｂ，５ｃ内に挿入された変形防止材７，７，…の存在により、複数層積層された圧電素子５ａ～５ｃの全体を焼成する際に反りの発生を少なくし、仕上がりの寸法サイズを高精度とすることができる。このように作製された超音波振動子１は、例えば上記内部電極６ａ，６ｂを境にして３層に積層された圧電素子５ａ，５ｂ，５ｃの厚さがそれぞれ0.21mmとなり、全体の厚さが0.63mmとなる３層の積層構造の超音波振動子と等価となる。

【００２８】その後、図２に示すように、上記超音波振動子１の背面側にその背面から出る超音波が再び振動子面に戻ってこないようにするバッキング材２を設けると共に、上記超音波振動子１の前面側には該超音波振動子１の音響インピーダンスと生体の音響インピーダンスとの整合をとる音響整合層３ａ，３ｂを設ける。これにより、本発明の超音波探触子が製造される。

【００２９】なお、上記超音波探触子の製造工程において、図４に示すように超音波振動子１が作製されたところで、該超音波振動子１を所定のピッチ幅ｐ，ｐ，…で短冊形に切断してアレイ状に形成してもよい。この場合は、多数の振動子素子をアレイ状に配列した電子走査型の超音波探触子を製造することができる。

【００３０】図５及び図６は超音波探触子の製造方法の他の例を示す説明図である。この例による製造方法は、基本的には図３及び図４に示す製造方法と同一であるが、圧電材料を用いて所定の厚さで平板状の圧電素子片９，９，…を形成した後、上記圧電素子片９の片面に図２に示す内部電極６ａ，６ｂとなる導電ペースト１０を印刷塗布する際に、その両側辺部に導電ペースト１０の塗布されていない絶縁部分１１を形成したものである。なお、このとき、実際に図２に示す内部電極６ａ，６ｂとなる導電ペースト１０を印刷塗布する際は、外部電極８ａ，８ｂと接続する側には絶縁部分１１を形成しないようにする。

【００３１】このような状態で、図６に示すように、９層の圧電素子片を積層すると共に内部電極６ａ，６ｂ及び変形防止材７，７，…を形成し、かつ上面及び下面に外部電極４ａ，４ｂを形成し、さらに両側面に側部電極８ａ，８ｂを形成する。そして、上面の外部電極４ａと連続する側部電極８ａを一方の内部電極６ｂに接続し、下面の外部電極４ｂと連続する側部電極８ｂを他方の内部電極６ａに接続する。このように製造することにより、図４において側部電極８ａ，８ｂの内側面と９層の圧電素子片の側端部との間に絶縁物を充填することを要せず、製造工程を簡略化できる。

【００３２】

【発明の効果】本発明による超音波探触子は以上のよう

に構成されたので、その超音波振動子を、所定の厚さの板状に形成された圧電素子を複数層積層し、この複数層積層された圧電素子の全体の上面及び下面に外部電極を形成すると共に、各層の境目には平板状の内部電極をそれぞれ形成し、かつ上記圧電素子の各層の厚み内には一又は複数の平板状の変形防止材を等間隔で挿入し、上記上面の外部電極及び下面の外部電極をそれぞれ１層おきに異なる内部電極に対し接続すると共に、各層内の平板状の変形防止材とは絶縁し、この状態で上記複数層積層された圧電素子の全体を積層方向に交互に逆向きに分極した構造としたことにより、上記変形防止材の挿入によって複数層積層された１層当たりの厚さを実質的に薄くできると共にその変形防止材の存在により、上記複数層積層された圧電素子の全体を焼成する際の反りの発生を少なくし、仕上がりの寸法サイズを高精度とすることができる。従って、本発明による超音波探触子によれば、単一共振周波数の振動モードが得られ、超音波診断装置として画質のよい超音波画像を得ることができる。

【００３３】特に、上記圧電素子の各層の厚み内に挿入された変形防止材を、内部電極と熱膨張率が同一又は同等の材料から成るものとした場合は、複数層積層された圧電素子の全体を焼成する際の反りの発生をさらに少なくし、仕上がりの寸法サイズをさらに高精度とすることができる。

【００３４】また、本発明による超音波探触子の製造方法によれば、複数層積層された圧電素子の全体を焼成する際の反りの発生を少なくし、仕上がりの寸法サイズが高精度な超音波振動子を容易に作製することができる。

【図面の簡単な説明】

【図１】本発明による超音波探触子の実施の形態を示す一部断面斜視図である。

【図２】図１のＡ－Ａ線断面図である。

【図３】上記超音波探触子の製造方法の工程の一部を示す斜視説明図である。

【図４】上記超音波探触子の製造方法で作製した超音波振動子を示す斜視説明図である。

【図５】他の例による超音波探触子の製造方法の工程の一部を示す斜視説明図である。

【図６】上記超音波探触子の製造方法で作製した超音波振動子を示す断面説明図である。

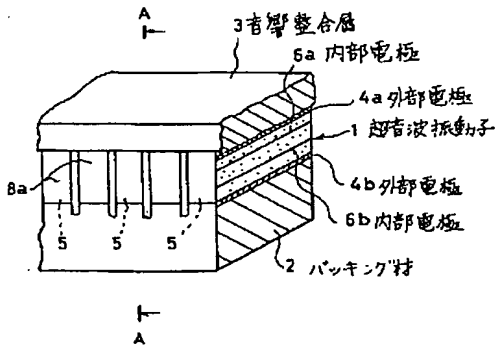
【図７】従来の超音波探触子を示す一部断面斜視図である。

【図８】従来の複数層積層構造の超音波振動子を有する超音波探触子を示す一部断面斜視図である。

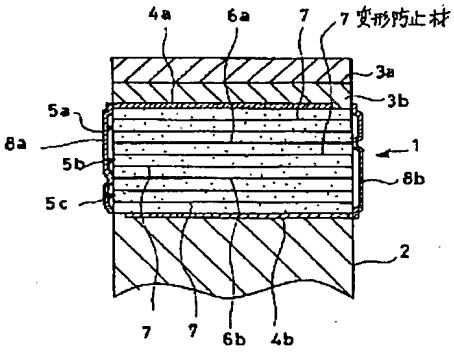
【符号の説明】

１…超音波振動子
２…バッキング材
３，３ａ，３ｂ…音響整合層
４ａ，４ｂ…外部電極
５…振動子素子
５ａ，５ｂ，５ｃ…圧電素子
６ａ，６ｂ…内部電極
７…変形防止材
８ａ，８ｂ…側部電極
９…圧電素子片
１０…導電ペースト
１１…絶縁部分

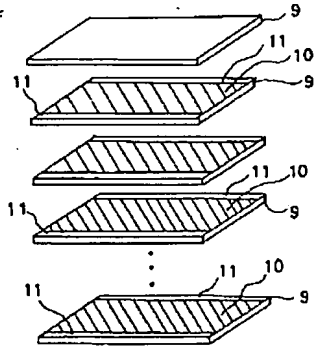
【図１】



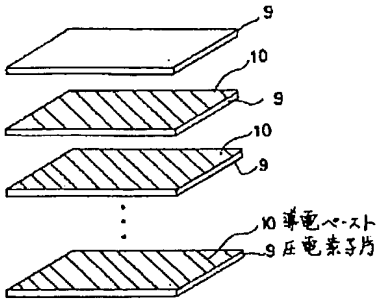
【図２】



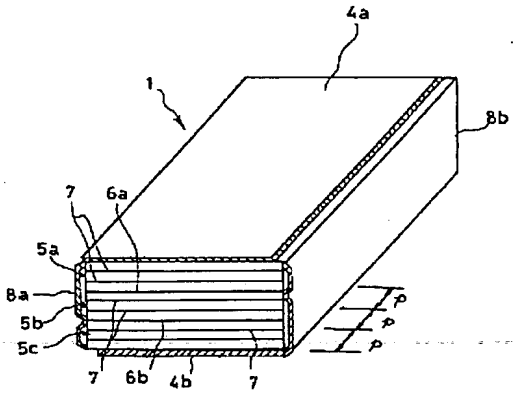
【図５】



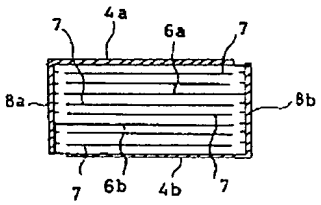
【図３】


9
10
9
10
9
10 導電ペースト
9 圧電素子片

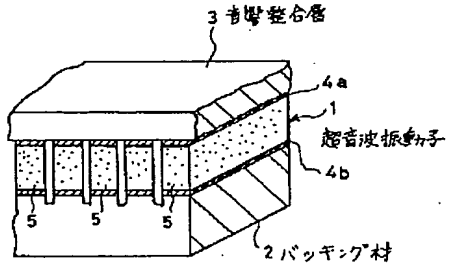
【図４】


4a
1
8b
7
6a
5a
8a
5b
5c
P
P
P
7
6b
4b
7

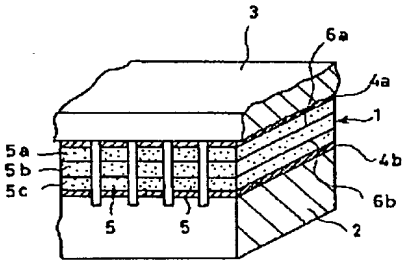
【図６】


7
4a
6a
7
8a
8b
7
6b
4b
7

【図７】


3 音響整合層
4a
1
超音波振動子
4b
5
5
5
2 バッキング材

【図８】


3
6a
4a
1
5a
5b
5c
4b
6b
5
5
2